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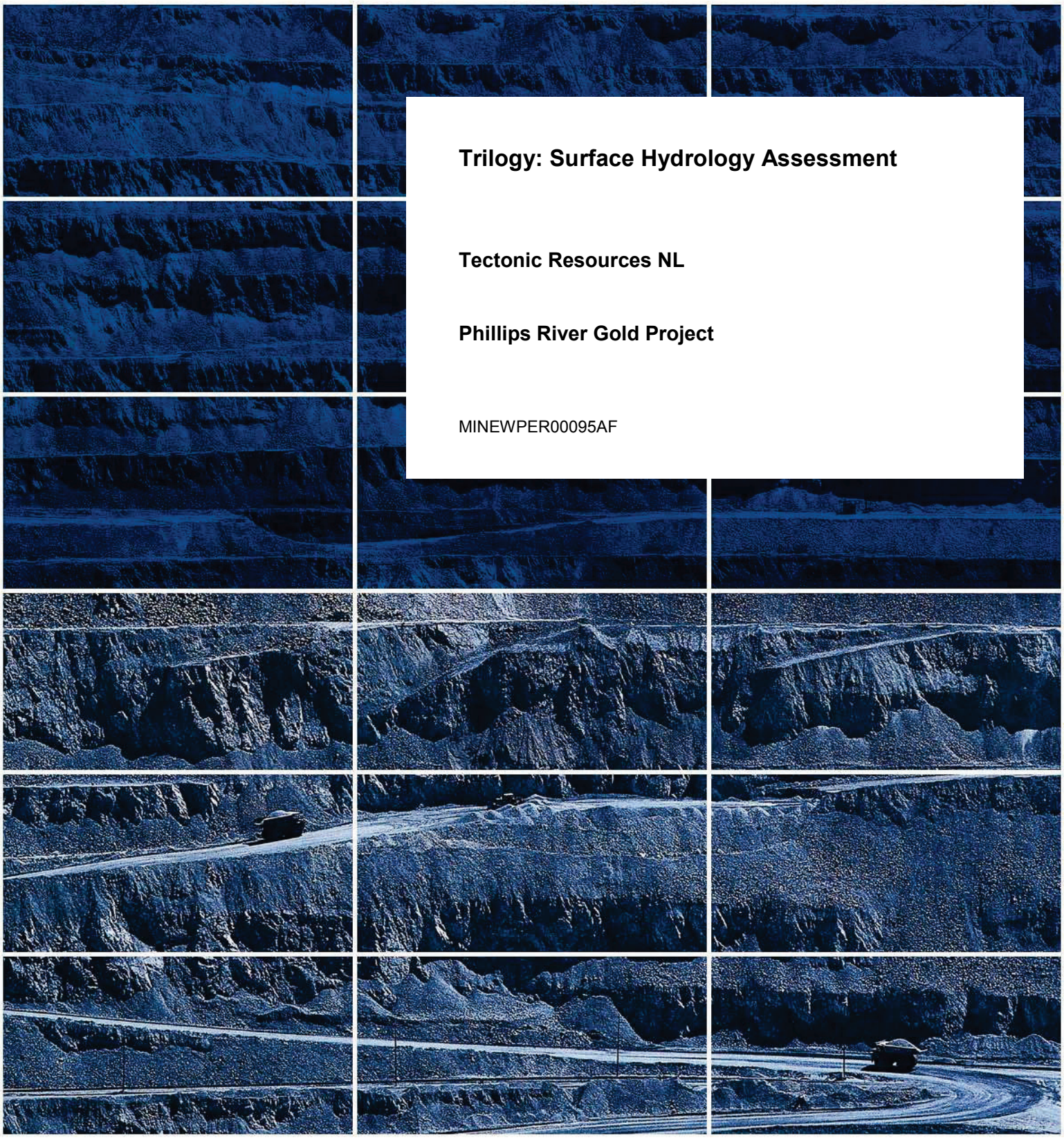

Trilogy: Surface Hydrology Assessment

Tectonic Resources NL

Phillips River Gold Project

MINEWPER00095AF

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13 April 2011

Tectonic Resources NL
Unit 46
328 Albany Highway
Victoria Park, WA, 6100.

Attention: Mr Jason Stirbinskis

Dear Sir

RE: Trilogy: Surface Hydrology Assessment

Please find attached two copies of our design report.

Should you have any queries, please don't hesitate to contact this office.

For and on behalf of Coffey Mining Pty Ltd

Christopher Hogg
Principal Civil / Geotechnical Engineer

Attachment: Trilogy: Surface Hydrology Assessment – Design report

MINEWPER00095AF

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Rev A	Issued for client's review and comments	Fanie vd Linde	23 Feb 2011
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Document Review and Sign Off

Fanie van der Linde
Senior Civil / Geotechnical Engineer

Christopher Hogg
Principal Civil / Geotechnical Engineer

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1 INTRODUCTION

Coffey Mining Pty Ltd were commission by Tectonic Resources NL to describe the surface hydrology of the Kundip Project site and recommend surface drainage controls appropriate to the proposed mine infrastructure as part of the preparation of the Mining Proposal for the project.

The proposed Trilogy Project comprises an open pit mine, processing plant and associated facilities. Polymetallic ore will be sourced from Trilogy with gold ore from Kundip processed at a later date.

The objectives of this study are as follows:

- Identify surface runoff catchments and drainage routes
- Estimate peak flows for existing conditions
- Assess proposed infrastructure layout and recommend drainage controls were necessary

JDA conducted a hydrology study of the Trilogy project in 2005 (refer JDA, 2005[1]). This report updates that study and presents the results of new analysis for the changed project layout.

2 CATCHMENT DESCRIPTION

2.1 Location

The Trilogy site is located approximately 27km south-east of Ravensthorpe on the Hopetoun - Ravensthorpe Road. The proposed development is within Myamba Farm, with farming intended to continue in the other parts of the farm during mining.

2.2 Climate

The climate at Trilogy is similar to Ravensthorpe and is characterised by consistent rainfall throughout the year with a mean annual rainfall of approximately 430mm per year (Table 1). Class A pan evaporation for Ravensthorpe of 1987mm is approximately 4 times mean annual rainfall (JDA, 2005[1]).

2.3 Soils

Soils from the Trilogy Project area sampled in 2010 were found to be structurally unstable. The soils at the surface (0-5cm) generally slaked and were partially dispersive, particularly upon disturbance. The degree of dispersion typically increased with depth below the surface layer, with completely dispersive soils identified below the surface sampling interval at the majority of sites. Some samples displayed a capacity for hard setting and are likely to form a crust upon wetting / drying. The red clay-dominated soils, representing the most common soil type in the Project area, were classed as sodic with an average exchangeable sodium percentage of 6.12%. (Outback Ecology, 2004[6] and info from forthcoming Outback Ecology soils report).

Table 1

Climatological Summary for Ravensthorpe for Data 1901 to 2010

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean Daily Maximum Temperature	28.9	28.4	26.6	23.6	20.1	17.2	16.3	17.2	19.4	22.3	25.0	27.2	
Mean Daily Minimum Temperature	14.0	14.5	13.6	11.7	9.6	7.8	6.7	6.6	7.3	8.9	11.0	12.7	
Mean Monthly Rainfall (mm)	25.1	24.7	31.1	33.6	44.2	43.6	46.8	44.7	41.6	37.7	30.0	22.5	425.6

Source: Bureau of Meteorology

2.4 Topography

The topography of the area is characterised by low hills with very gentle slopes (2 to 3%). Stream channels within the landscape are widely spaced forming an integrated network of convergent creeks (Figure 1).

Maximum elevation is the in the north of the Trilogy site at approximately 90m AHD, falling to 80m AHD at the southern end of site.

2.5 Surface Drainage Features

Surface drainage is north to south from the ranges towards the Southern Ocean. The main drainage arteries in the immediate Trilogy area are the Phillips River, Steere River and Jerdacuttup River. The Phillips and Steere Rivers discharge to Culham Inlet just north-west of Hopetoun, while Jerdacuttup River discharges to Jerdacuttup Lakes to the east of Hopetoun (Figure 1).

The proposed Trilogy Project drains south by Kuliba Creek, a tributary of the Steere River. Kuliba creek intersects the Steere River on the west side of Ravensthorpe-Hopetoun Rd, approximately 8km south- west of the Study Area.

3 RUNOFF ESTIMATES: EXISTING CATCHMENT

3.1 Sub-Catchments

There are 2 sub-catchments of Kuliba Creek identified within the Study Area as shown in Figure 2. The estimated area for these sub-catchments is presented in Table 2 below.

Table 2
Estimated Area of Sub-Catchments

Sub-Catchment	Estimated Area (ha)	% Cleared
A	345	75
B	432	75
Total	**777**	**75**

3.2 Land Use

The Study Area occurs on cleared farmland (Myamba Farm) with only isolated pockets of perennial vegetation remaining. The area is closely grazed with pasture cover varying seasonally. A number of existing farm dams used for stock watering intercept the flow of the creeks.

3.3 Estimated Peak Flows

Due to the lack of gauged flow data on the Steere River, the Rational Method of flood estimation was adopted as recommended in Australian Rainfall and Runoff (AR&R, 2000[3]). The Rational Method provides peak flow estimates up to the 50 year Average Recurrence Interval (ARI). For the 100 year ARI, the peak flow was estimated by extrapolation. The extrapolation to the 100yr ARI is based on a linear extension between the 50yr and 100yr ARI using a ratio of 1.4.

The Trilogy Site is within the Wheatbelt Zone for flood estimation (AR&R, 2000[3]). Based on the catchment characteristics of the Study Area, equations for loamy soils 75-100% cleared were adopted (AR&R, 2000[3]). Analysis of rainfall intensity and duration (Figure 3) was carried out using procedures described in Book 2 of AR&R (2000[3]).

Data sheets for flood estimation for each sub-catchment are included as Appendix A, with calculated flows presented in Table 3.

Table 3
Peak Flow Estimates: Existing Condition

Creek[1]	Flow Peaks (m^3/s)	
	50 year ARI	100 year ARI
A	16.9	22.9
B	21.2	28.7

Notes: 1. Creek is annotated in accordance with its associated sub-catchment name.

The accuracy of the Rational Method in predicting floods on ungauged catchments, such as the Steere River, is only known for the 10 year ARI. For this event we can be 68% sure that the true value is between half and twice the estimated value (JDA, 2005[1]). Rarer flood estimates are less certain, but can still be considered the best estimates available.

4 PROPOSED MINES & INFRASTRUCTURE

4.1 Site Access & Layout

Access to the Trilogy site is from Ravensthorpe-Hopetoun Road to the west of the site. The general layout of the site includes an open cut pit, waste dump, process plant, Run of Mine (ROM) pad and a water storage facility (Figure 4).

4.2 Roads

The main access road is approximately 1.4km in length and connects the Trilogy Site to Hopetoun-Ravensthorpe Road. The road will have a proposed running width of 11m with 1:3 side batters.

Haul roads within the site currently marked out on Figure 4, are 22m wide with 1:3 side batters, which connects the Pit with the ROM pad and plant site.

4.3 Pit & Waste Rock Landform

The development includes an open pit followed by an underground operation, with an associated waste rock landform. The pit covers an area of 19.3ha and the waste rock landform 94.4ha. The waste rock landform is located on the north-western side of the pit, north of the plant site (Figure 4). The ROM pad covers an area of approximately 8.6ha.

4.4 Water Storage Facility

The water storage facility is located 350m south of the plant site and covers an area of 22.8ha. The facility is designed to contain dewatering discharge from the pit and has a large surface area to facilitate evaporation.

5 RUNOFF ESTIMATES: DURING MINING OPERATIONS

5.1 Sub-Catchments

Based on the proposed mine site layout the sub-catchment areas and level of clearing will change due to the construction of infrastructure, namely Trilogy pit, the waste rock landform, ROM pad, Water Storage Facility, Plant site, Haul roads and access. Some access roads are existing and just need to be upgraded.

Tectonic NL proposes to re-vegetate a number of corridors along the main access road and Creek A, a total area of between 5 and 10 hectares. We would not expect the vegetation to mature enough in the life of the mine to have a significant effect on the runoff rate.

As the catchments are already heavily cleared, the change in clearing from mining will be only minor. Table 4 shows the revised sub-catchment characteristics indicative of the proposed mine site layout.

Table 4
Sub-Catchment Characteristics During Mining Operations

Sub-Catchment	Estimated Area (ha)	% Cleared
A	291.9	75
B	213.8	75
C	48.0	75
D	16.8	100
E	23.8	100
F	18.3	100
G	12.5	100
H	10.8	100
I	56.4	75
J	111.8	75
Total	**768.7**	**88**

5.2 Estimated Peak Flows

Peak flows have been estimated based on the revised sub-catchment characteristics and are presented in Table 5.

Table 5
Peak Flow Estimates: During Mining Operations

Sub-Catchment No.	Flow Peaks (m^3/s)	
	50 year ARI	100 year ARI
A	14.3	19.4
B	10.5	14.2
C	5.7	7.8
D	4.2	5.8
E	3.7	5.0
F	4.6	6.4
G	3.2	4.3
H	2.7	3.7
I	5.8	7.8
J	7.1	9.7

6 RELEVANT DESIGN CRITERIA

The Department of Industry and Resources (2006[2]) Mining Environmental Management Guidelines for mining projects in WA includes the following specific requirements relevant to this report.

- **Existing Environment – Hydrology (page 15)**
  - "A brief description of surface and sub-surface water flows with assessment for flood potential…"
  - "Provide details of any water management areas such as water reserves, declared or proposed water supply catchment areas...in or near the project area."
- **Existing Environment – Climate (page 15)**
  - "The MP should contain meteorological information necessary to adequately assess and manage all climatic impacts that could have significant impact on the project. Minimum drainage design should be based on at least the one in 100 year 72 hour duration rainfall event."
- **Environmental Impacts and Management – Land Clearing (page 19)**
  - "The impacts of land clearing and vegetation removal on soil erosion, salinity and hydrology should be assessed and described…."
  - "Land management and drainage strategies should be considered along with factors like the cleared area's shape and landform profile, water control…"
- **Environmental Impacts and Management – Water (page 19)**
  - "The impact of flooding on the mine site, if applicable, should be addressed."
  - "Any potential impacts of any hydrological changes on vegetation, habitat or aquatic ecosystems should also be discussed."

Coffey Mining Pty Ltd understands that all other MP requirements will be addressed separately to this report.

7 SURFACE WATER CONTROLS

7.1 General

An outlay of the proposed surface water control treatments as described below are presented in Figure 5. The aim will be to optimise flood control and surface water resources. As the area is already heavily cleared the additional runoff generated by the construction of the mine infrastructure should be minor. The diversion of clear water around the proposed infrastructure is described in more detail under section 7.2. Additional polluted / contaminated runoff from the waste rock landform can be attenuated on site by means of sumps. The sump water can be used within the mine operation, while seeking to maintain environmental flows in the creeks at existing rates as far as possible.

7.2 Diversion of Creek A and Creek B

The proposed waste rock landform is located on the creek line of Creek A. The estimated flow in Creek A for the developed catchment at this location would be 19.4m³/s for the 100yr ARI. The proposed pit is located on the creek line of Creek B. The estimated flow in Creek B for the developed catchment at this location would be 17.1m^3/s. Trapezoidal open drains with the dimensions shown in Table 6 would be able to contain these flows around the facilities. Refer to Figure 5 for location of these and other proposed open drain facilities across proposed mine site development.

Table 6
Estimated Open Drain Dimensions

Diversion Drain no.	Design Flow (m³/s)	Base Width (m)	Side Batter (v:d)	Mainstream Average Grade (v:d)	Roughness 'n'	Flow Depth (m)
A	19.4	12	1:3	1:500	0.06	1.5
C	17.1	10	1:3	1:143	0.06	1.1
D	5.8	5	1:3	1:200	0.06	0.9
E	5.0	5	1:3	1:250	0.06	0.9
F	6.4	5	1:3	1:330	0.06	1.1
G	4.3	5	1:3	1:165	0.06	0.8
H	6.2	5	1:3	1:125	0.06	0.8
I	12.9	10	1:3	1:1000	0.06	1.5

7.3 Roads

Road drainage around the Trilogy Site will need to be management by incorporating road side drains into road designs. With the road drain flows can be controlled by use of energy dissipaters, drop structures and sediment controls.

Road crossings are required where the proposed roads intersect creek lines (Figure 5).

Proposed concrete pipe culvert details for road crossing 1-5 are summarised in Table 7:

Table 7
Concrete Pipe Culvert Details – Assuming Inlet Control

Road Crossing no.	Design Flow (m³/s)	Design Capacity (m³/s)	Pipe Diameter (mm)	Mainstream Average Grade (v:d)	Roughness 'n'	Number of barrels
1	13.4	13.4	1500	1:50	0.012	2
2	4.9	4.9	1050	1:50	0.012	2
3	25.7	26.9	1500	1:50	0.012	6
4	27.2	26.9	1500	1:50	0.012	6
5	4.3	4.5	900	1:50	0.012	3

7.4 Runoff Erosion Controls

Due to the physical characteristics of the soil identified by Outback Ecology (2004) runoff erosion controls will be required for all cleared areas, including the waste dump and ROM pad which cover areas of 94.4 and 8.6ha respectively. The additional runoff from these areas will be managed by the open drain network, to ensure erosion of the surrounding landscape does not occur. Erosion within the drainage channels should not be considered a problem, for the velocities of the water flow are designed to be around 1m/s - slow enough not to be causing any damage. A total seepage volume of approximately 0.022m^3/day is expected to flow into the drainage channels surrounding the proposed TSF, thus contaminating surface runoff (Coffey Mining, 2010[7]).

7.5 Flood Mitigation and Ponding Controls

To prevent flooding of infrastructure and unwanted ponding of stormwater around the pit, waste dump, ROM, plant site and water storage facility, appropriate water control bunds together with open drains and sumps, should be incorporated in to the designs of these structures. Additional runoff from the waste rock landform will be diverted to be attenuated on site by means of sumps. The sumps must at least be sized to hold the volume of runoff generated by the one in 20 year 24 hour duration rainfall event, which implies that the capacity of the sump north of the pit and the sump south of the plant site should be 21000m^3 and 14000m^3 respectively.

7.5.1 Trilogy Pit

The pit will be located in the centre of Creek B alignment and as such surface flows towards the pit should be relatively major. Due to the proximity of the waste rock landform, additional runoff from the rock landform will need to be managed and directed away from Trilogy Pit. Appropriate water control bunds, open drains and sumps should be installed around the pit to prevent any surface flows from entering the pit (Refer to Figure 5 for proposed open drain configuration). Open Drain C will divert surface flow from Creek B around the eastern side of the pit, while surface flow from the waste rock landform will be diverted through open drain D and F to be attenuated in the proposed sump to be located just north of Trilogy pit.

7.5.2 Waste Rock Landform

The waste rock landform is located in the centre of Creek A and as such surface flows towards the rock landform should be relatively major. Appropriate water control open drains should be installed to prevent any erosion from the surface flows around the base of the facility, as shown in Figure 5. Open drain A will divert surface flow from Creek A in a westerly direction towards the creek flowing from north to south, situated west of the waste rock landform. Open drain G will divert the surface water from the waste rock landform in a southerly direction, to be attenuated in a proposed sump to be located between the ROM and the process plant. Open drain E and I will divert the surface water from the waste rock landform in a southerly direction, to be attenuated in a proposed sump to be located next to the water storage facility.

8 CONCLUSIONS

- The proposed Trilogy Project comprises an open pit mine, processing plant an associated facilities. Polymetallic ore will be sourced from Trilogy, with gold ore from Kundip to be processed at a later date.
- There are 2 sub-catchments of Kuliba Creek within the Study Area which are tributaries of the Steere River.
- Peak flows have been estimated for each sub-catchment based on the Rational Method described in Australian Rainfall & Runoff (2000[3]).
- Due to the lack of gauged data for rivers in the Esperance Coast area, the peak flows are indicative only.
- The diversion of Creek A and Creek B is necessary for construction of the waste rock landform and the pit.
- Flood estimates in this report should be reviewed as the site planning and construction progresses.

9 REFERENCES

1. JDA, Consultant Hydrologists (2005) *Kundip Notice of Intent: Surface Hydrology Assessment*. Report to Tectonic Resources NL.
2. Department of Industry and Resources (2006) *Mining Environmental Management Guidelines* Environmental Division. Mining Proposals in WA.
3. The Institution of Engineers Australia (2000) *Australian Rainfall & Runoff. Volume 1: A Guide to Flood Estimation*. The Institution of Engineers Australia.
4. The Institution of Engineers Australia (1987) *Australian Rainfall & Runoff. Volume 2: A Guide to Flood Estimation*. The Institution of Engineers Australia.
5. Bureau of Meteorology – Western Australia
6. Outback Ecology Services (2004) *Topsoil characterisation at Kundip and Trilogy and recommendations for rehabilitation.* Report to Tectonic Resources NL.
7. Coffey Mining Pty Ltd (2010) *Definitive Feasibility Study – Integrated Waste Landform Tailings Storage Facility (IWL TSF) Trilogy Project.* Draft Report to Tectonic Resources NL.

Figures

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approved	CH		project:	SURFACE WATER HYDROLOGY - TRILOGY	
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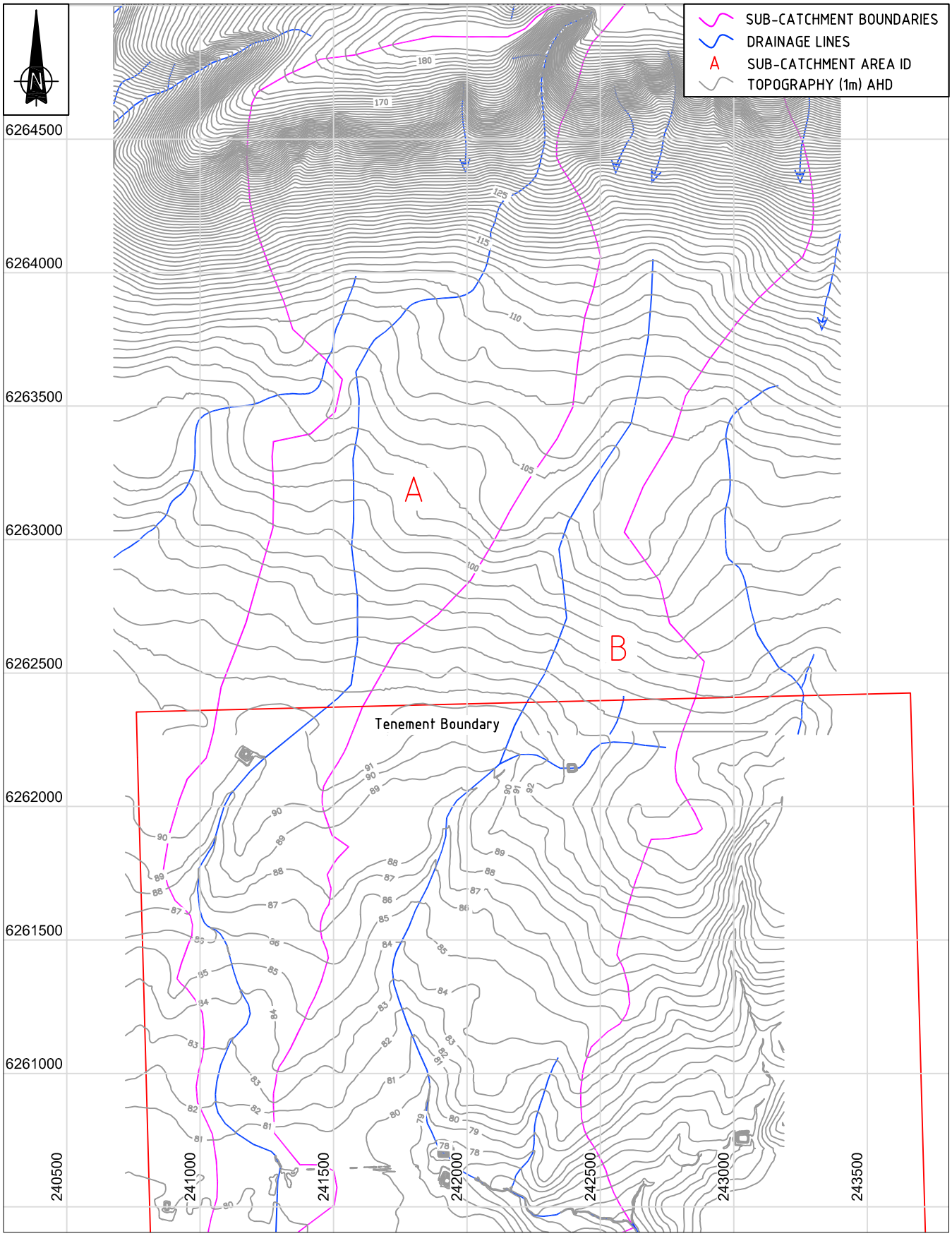

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Client: TECTONIC RESOURCES NL

Project: SURFACE WATER HYDROLOGY - TRILOGY

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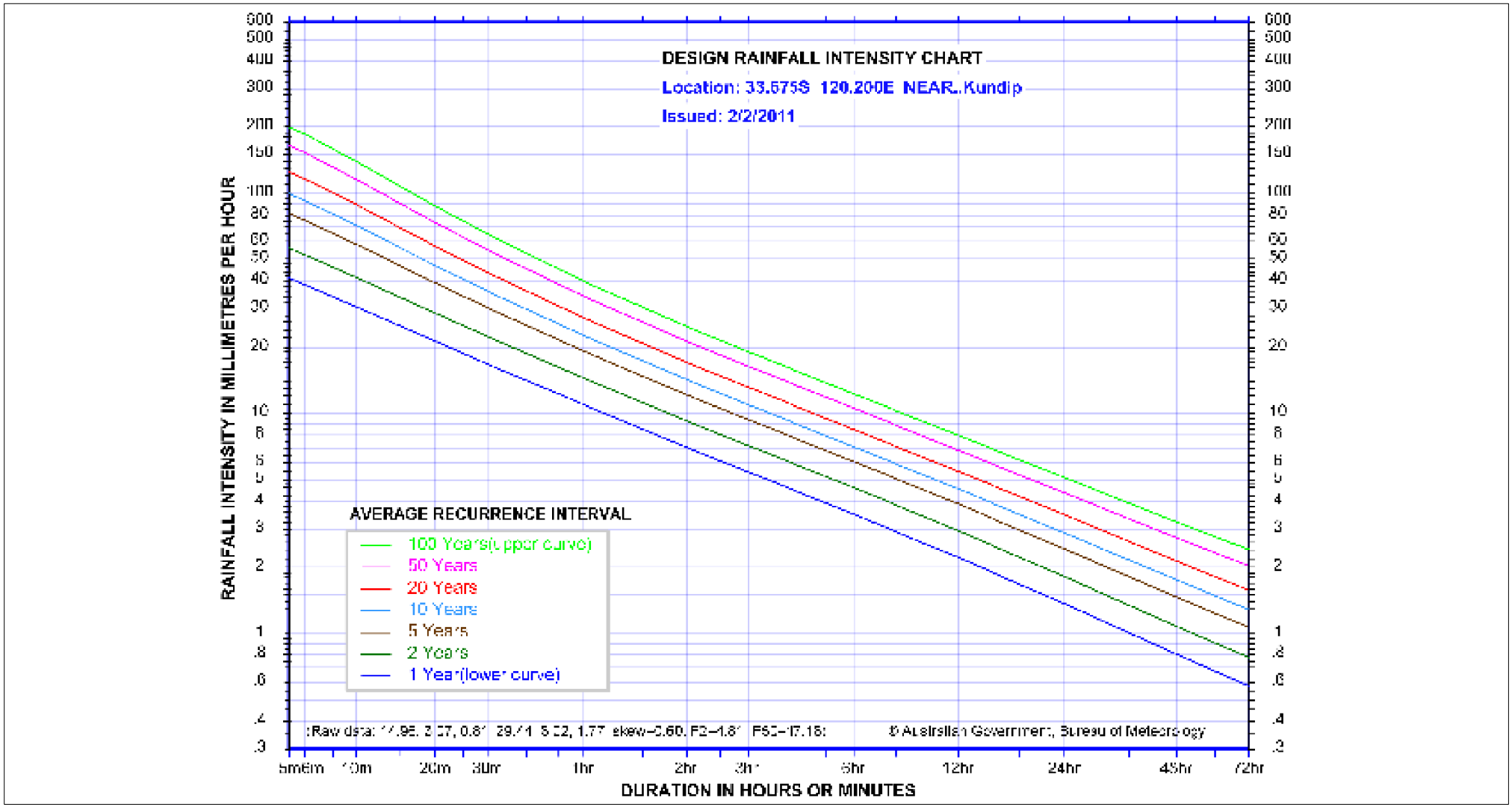
Project no: MWP00095AF | Fig no: 2 | Rev: A



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Project: SURFACE WATER HYDROLOGY - TRILOGY

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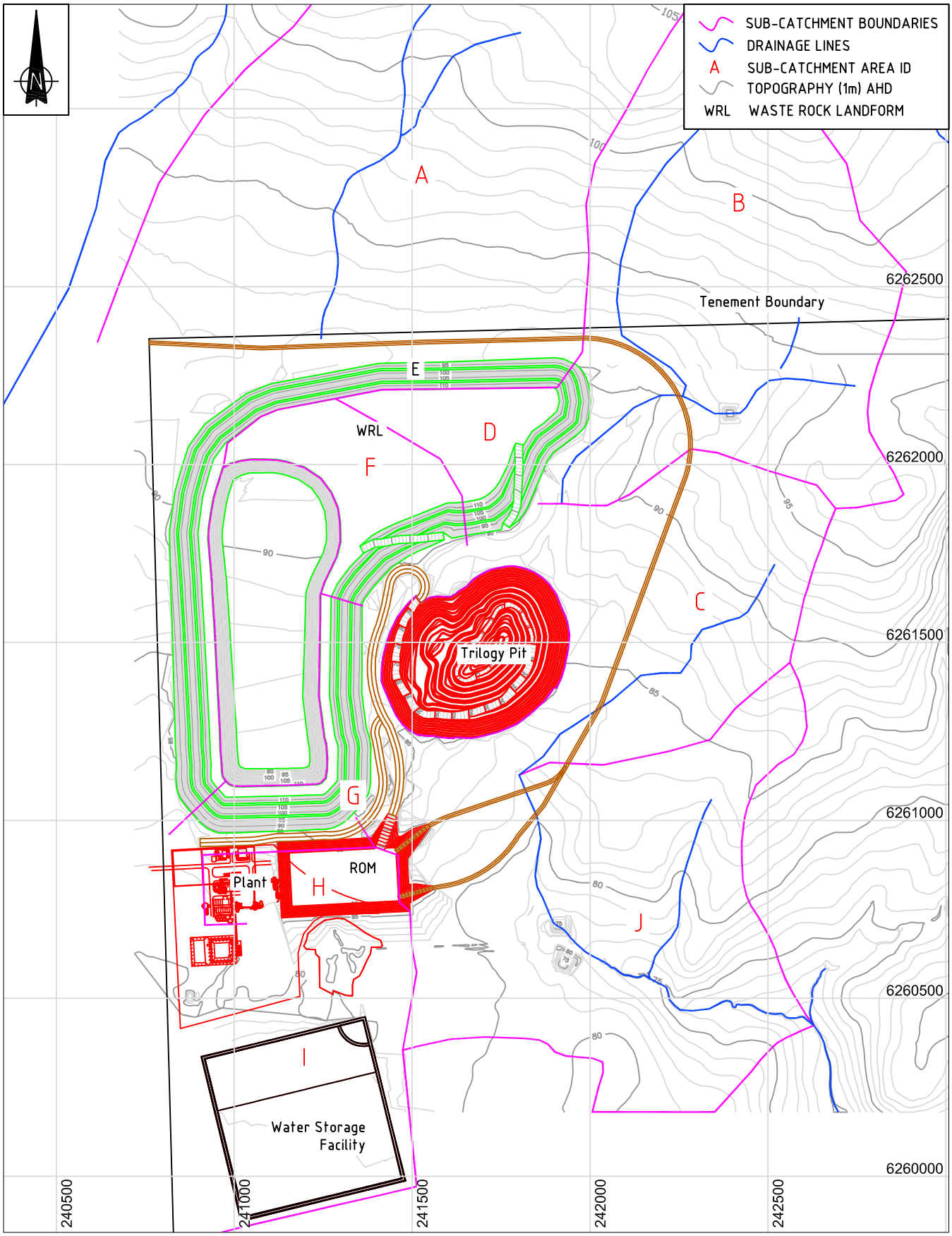

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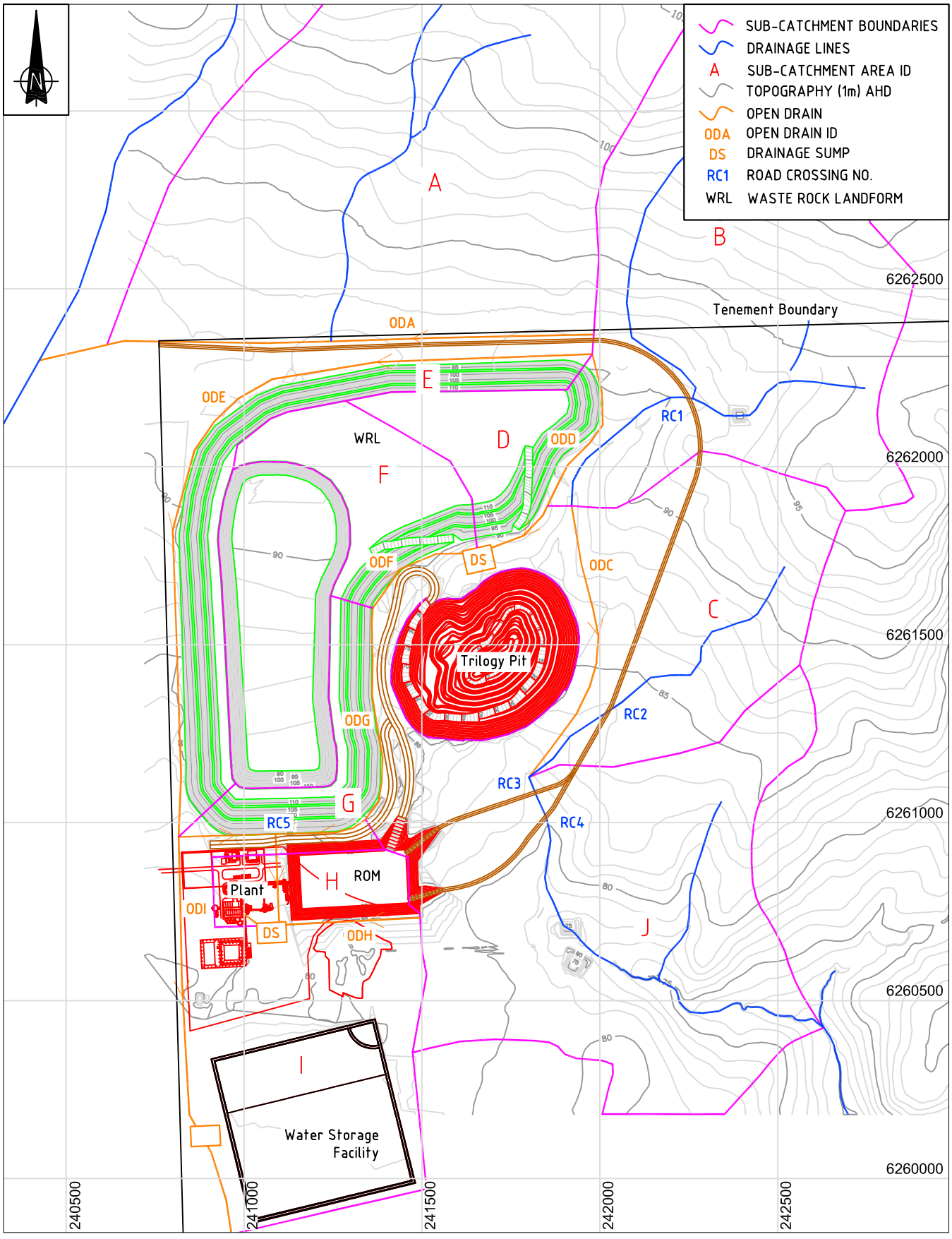
Project: SURFACE WATER HYDROLOGY - TRILOGY

Title: PROPOSED SITE LAYOUT PLAN

Project no: MWP00095AF | Fig no: 4 | Rev: A



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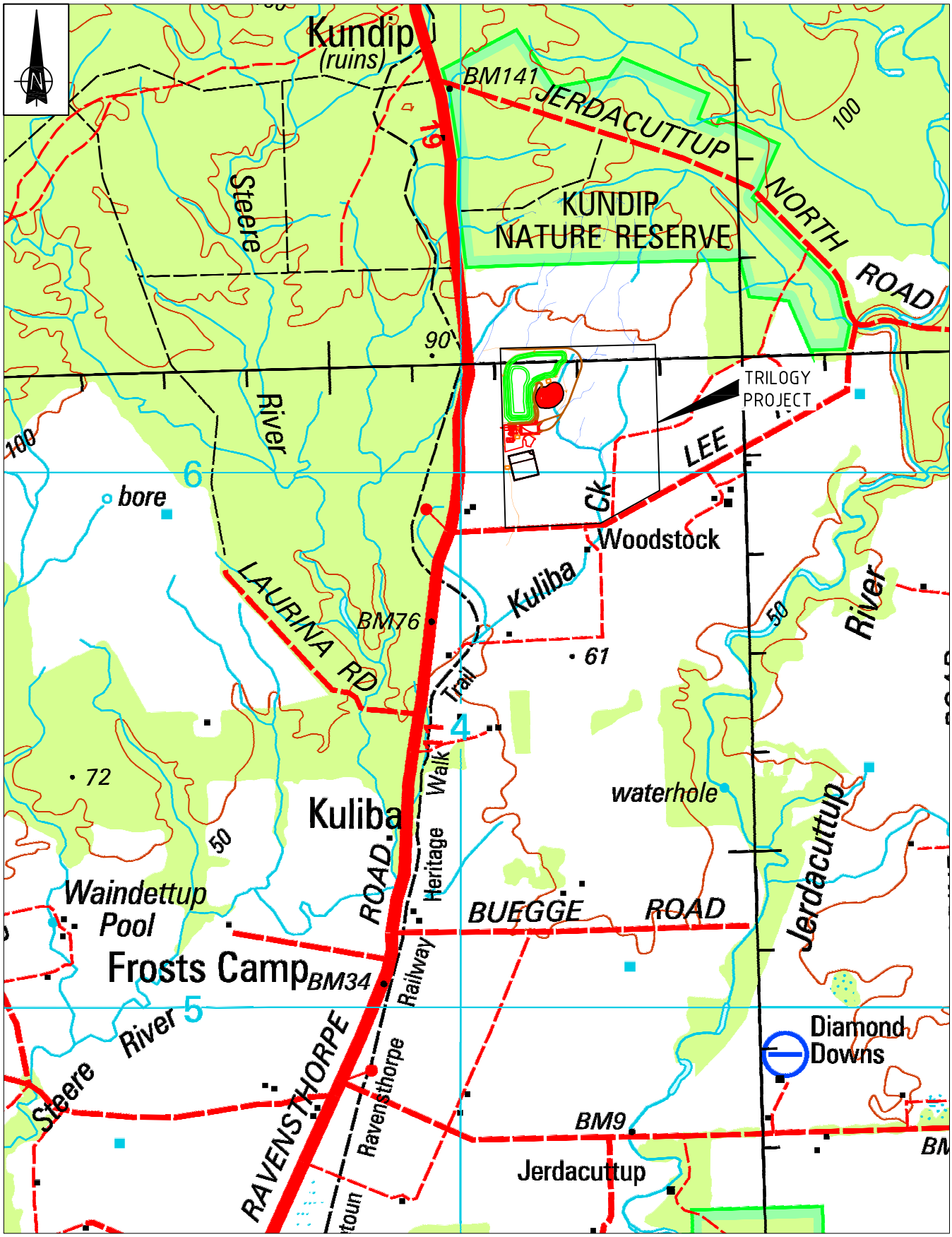

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Client:	TECTONIC RESOURCES NL
Project:	SURFACE WATER HYDROLOGY - TRILOGY
Title:	SURFACE WATER DRAINAGE - REGIONAL CONTEXT
Project no:	MWP00095AF
Fig no:	6
Rev:	A

Appendix A

Flood Estimation Data Sheets

Detailed calculation of Peak Flow Rates
Tectonic: Trilogy

Time of Concentration (tc):

Description	Label	Catchment area, A (m2)	Catchment area, A (km2)	Clearing, C_L (% of A)	Time of concentration t_c (min)	C_{10}	C_Y/C_{10} for ARI (years)							$I_{tc,Y}$ for ARI (years), (mm/h)							Q_Y for ARI (years), (m^3/s)						
							1	2	5	10	20	50	100	1	2	5	10	20	50	100	1	2	5	10	20	50	100
Trilogy Pre-project:																											
Catchment A	A	3,450,236	3.450	75%	271	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	5	7	9	11	13	16	19	1.78	2.98	5.48	8.00	11.52	16.94	22.93
Catchment B	B	4,317,656	4.318	75%	305	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	5	7	9	11	13	16	19	2.23	3.73	6.86	10.01	14.42	21.20	28.69

Detailed calculation of Peak Flow Rates
Tectonic: Trilogy

Time of Concentration (tc):

Description	Label	Catchment area, A (m2)	Catchment area, A (km2)	Clearing, C_L (% of A)	Time of concentration t_c (min)	C_{10}	C_Y/C_{10} for ARI (years)							$I_{tc,Y}$ for ARI (years), (mm/h)							Q_Y for ARI (years), (m^3/s)						
							1	2	5	10	20	50	100	1	2	5	10	20	50	100	1	2	5	10	20	50	100
Trilogy Post-project:																											
Catchment A	A	2,919,014	2.919	75%	247	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	5	7	9	11	13	16	19	1.51	2.52	4.64	6.77	9.75	14.33	19.40
Catchment B	B	2,137,822	2.138	75%	209	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	5	7	9	11	13	16	19	1.11	1.84	3.40	4.96	7.14	10.50	14.21
Catchment C (Channel)	C	126,731	0.127	75%	45	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.20	0.34	0.65	0.96	1.40	2.10	2.89
Catchment D	D	167,836	0.168	100%	53	1.15	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.41	0.69	1.31	1.94	2.83	4.24	5.82
Catchment E	E	237,944	0.238	100%	64	1.15	0.45	0.57	0.80	1.00	1.20	1.42	1.65	11	15	19	23	27	34	40	0.38	0.63	1.17	1.73	2.49	3.70	5.03
Catchment F	F	183,101	0.183	100%	55	1.15	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.44	0.75	1.42	2.12	3.09	4.62	6.35
Catchment G	G	124,811	0.125	100%	45	1.15	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.30	0.51	0.97	1.44	2.11	3.15	4.33
Catchment H	H	107,792	0.108	100%	42	1.15	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.26	0.44	0.84	1.25	1.82	2.72	3.74
Catchment I	I	564,002	0.564	75%	102	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	11	15	19	23	27	34	40	0.59	0.98	1.83	2.69	3.88	5.76	7.83
Catchment J	J	1,117,755	1.118	75%	147	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	7	9	12	14	17	21	25	0.75	1.25	2.30	3.37	4.84	7.13	9.68

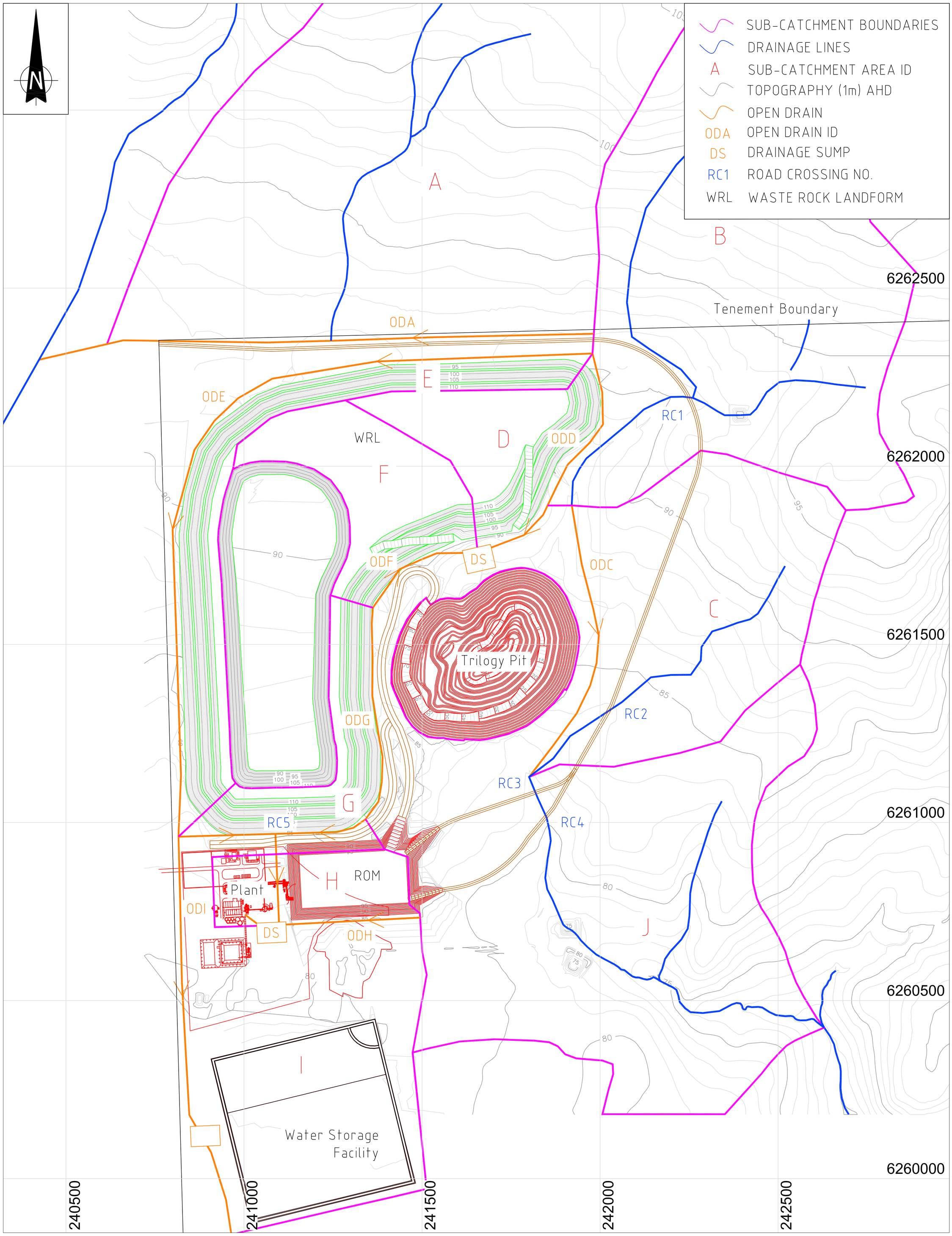
Detailed calculation of Peak Flow Rates
Tectonic: Trilogy

Time of Concentration (tc):

Description	Label	Catchment area, A (m2)	Catchment area, A (km2)	Clearing, C_L (% of A)	Time of concentration t_c (min)	C_{10}	C_Y/C_{10} for ARI (years)							$I_{tc,Y}$ for ARI (years), (mm/h)							Q_Y for ARI (years), (m^3/s)						
							1	2	5	10	20	50	100	1	2	5	10	20	50	100	1	2	5	10	20	50	100
Trilogy Post-project Road Crossings:																											
Road Crossing 1	RC1	2,022,457	2.022	75%	203	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	5	7	9	11	13	16	19	1.05	1.75	3.21	4.69	6.75	9.93	13.44
Road Crossing 2	RC2	353,563	0.354	75%	79	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	11	15	19	23	27	34	40	0.37	0.62	1.15	1.68	2.43	3.61	4.91
Road Crossing 3	RC3	160,445	0.160	75%	52	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.26	0.43	0.82	1.22	1.78	2.66	25.66
Road Crossing 4	RC4	66,338	0.066	75%	32	0.76	0.45	0.57	0.80	1.00	1.20	1.42	1.65	17	22	30	36	44	55	66	0.11	0.18	0.34	0.50	0.74	1.10	27.17
Road Crossing 5	RC5	Catch G																								3.15	4.33

Appendix B

Drawing



REF:
DWG: F:\MINE\Projects\Tectonic Resources\MINEWPER00095AF_Surface Water Hydrology-Kundip & Trilogy\Figures\Trilogy_Figure 5.dwg

Drawn:	**FVDL**
Approved:	**CH**
Date:	**2011-02-18**
Scale:	**1:15000**
Original size:	

coffey mining
SPECIALISTS FROM BOARDROOM TO MINE FACE

Client:	**TECTONIC RESOURCES NL**		
Project:	**SURFACE WATER HYDROLOGY - TRILOGY**		
Title:	**SURFACE WATER CONTROL TREATMENTS**		
Project no: **MWP00095AF**	Fig no: **5**	Rev: **A**	